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Serial No.: 09/826,341
Filing date: April 4, 2001

Examiner: K. Nguyen
Attorney Docket No.: 26445-1

REMARKS

Claims 1-12 are currently pending in this application. By virtue of this amendment claims 1-12 have been amended. Reconsideration and allowance of the above referenced patent application in view of the amendments made above and the remarks to follow is respectfully requested.

Amendments were made to all of claims 1-12 to correct informalities noted by the Examiner and to overcome the prior art of record.

Objections to the Specification

The Examiner has objected to the specification because of several informalities. In response, Applicants have amended the specification to address the concerns noted by the Examiner.

Claim Rejections under 35 U.S.C. §112, Second Paragraph

Claims 1-12 stand rejected under 35 U.S.C. §112, second paragraph as being indefinite for failing to point out and distinctly claim the subject matter of the invention.

In response, Applicants have amended the claims to address the rejections raised by the Examiner and more clearly define the invention.

Examiner rejected claims 3, 10, and 11 as being indefinite for reciting the limitation S/m. Applicants has amended claim 3 to specify electrical conductivity. However, Applicants respectfully disagree that the limitation S/m is indefinite. This term is adequately defined in the specification. Furthermore, S/m is a common unit for electrical conductivity, as is evidenced by the attached pages photocopied from *Perry's Chemical Engineers' Handbook*. Thus, a person of skill in the art would know that S/m refers to electrical conductivity and would be familiar with the units. Reconsideration and withdrawal of the rejection of claims 3, 10, 11 as being indefinite for reciting the limitation S/m is respectfully requested.

Claim Rejections Under 35 U.S.C. §102

The Examiner has rejected claims 1-12 under 35 U.S.C. §102(b) on the basis that the claims are clearly anticipated by Applicants' admission at page 2, line 11 through page 7, line 14 of the specification, Whitehouse et al. (5,844,237), Whitehouse et al. (5,306,412), Jorgensen et al. (5,115,131), and Wilm et al.

In response, Applicants have incorporated several limitations into independent claims 1 and 7, which are believed to render the invention patentable over the prior art of record.

In particular, claims 1 and 7 have been amended to require that the liquid be a non-corrosive and non-metallic liquid, and for the liquid to have a vapor pressure below 0.1 torr at 20 °C, a viscosity coefficient below 2 g/cm/s at 20 °C, and an electrical conductivity greater than 0.04 S/m at 20 °C. Claims 1 and 7 have also been amended to specify that the liquid is supplied to a region that is maintained at a low pressure, i.e., below 100 millitorr.

Applicants respectfully submit that the alleged admission by Applicants at the referenced pages do not describe or suggest all of the elements of Applicants amended claims. Furthermore, as discussed in detail below, none of the prior art references cited, alone or in combination, describe or suggest all of the elements of the claimed invention.

Whitehouse et al. (5,844,237) (See e.g., Abstract and Claim 1) and Wilm et al. (See e.g., Page 169) both describe an electrospray source that operates under atmospheric pressure. There is no teaching or suggestion in either reference that the electrospray source could operate in a region of low pressure, and in particular at a pressure of less than 100 millitorr, as required by Applicants claimed invention. Wilm et al. perform all their experiments with an API mass spectrometer, where API stands for Atmospheric

Pressure Ionization (See page 169, column 1). Thus the electrospray ions are first formed at atmospheric pressure, and are then introduced through a small orifice or a capillary into the vacuum system of a mass spectrometer. The drops and the ions are formed at atmospheric pressure, and ion formation requires drop evaporation and hence relatively high pressures. Wilm et al. specifically indicate (See page 169, column 2, lines 11-12) that “evaporation of droplets is achieved by a counter flow of heated nitrogen ...”. This would evidently be impossible in a vacuum where the drops move very fast, accelerated by the electric field and with hardly any resistance from background gas. They would have accordingly no time to evaporate before reaching the counter-electrode and losing their charge. In contrast, Applicants’ claimed invention produces the ions and the drops directly inside the vacuum system and does not require drop evaporation for ions to form.

Whitehouse et al. (5,306,412) do describe an electrospray source in an apparatus having components operating at low pressure (the mass spectrometer). But it is identical to the prior art in that the electrospray source where the drops (and then the ions) are formed is at relatively high pressure. This is clearly seen in Figure 1, where a counter flow gas (14) enters through the bottom and is directed against the atomizing tip 7 where the drops are produced. Whitehouse et al. (column 5, line 43) disclose that the drops “as they rapidly evaporate in route, the resulting solvent vapor along with any other uncharged material is swept back...”. None of this would happen in an environment at 100 millitorr or less. The ions formed at atmospheric pressure are transmitted to the vacuum system of the mass spectrometer (right end of Figure 1) by a small capillary (15), exactly as in the prior art systems. The capillary is the means to separate the high pressure end of the apparatus (where drops and ions are produced) from the vacuum end of the apparatus (where the analysis is performed). It plays very much the same role as the small inlet orifice in the commercial API mass spectrometer used by Wilm et al. The innovation of Whitehouse et al. (5,306,412) is based on the assistance of mechanical vibrations. In contrast, Applicants’ claimed invention does not use such vibrations. There is no teaching or suggestion in Whitehouse et al. that their source might work at pressures below 100 millitorr, and certainly no suggestion that high conductivities and low

volatilities might be of any advantage. The apparatus described by Whitehouse et al. (5,306,412) requires the assistance of mechanical vibrations. Furthermore, the apparatus described by Whitehouse et al. (5,306,412) does not use a fluid having all of the properties disclosed as essential elements of the claimed invention.

Furthermore, Jorgensen et al. also do not describe or suggest all of the elements of Applicants' claimed invention. While Jorgensen et al. do suggest operating the electrospray source in a region of low pressure, the liquid supplied to the region in Jorgensen et al. does not have the physical properties required by Applicants' claimed invention. In particular, Jorgensen et al. disclose that suitable solvent solutions include water, methanol, an acetonitrile, which are all solvents having a vapor pressure much higher than the vapor pressure of less than 0.1 torr at 20 °C, required by Applicants' claimed invention.

Applicants also note the following distinctions between the invention described by Jorgenson et al. and Applicants' claimed invention. Jorgensen et al. describe an electrospray source, which they distinguish in their specification from the prior art in two ways. A first difference is the use of capillary tubes with inner diameters smaller than 50 micrometers. In addition they maintain the pressure in the chamber surrounding the needle below 10 millitorr. However, they do not teach or suggest the use of low volatility liquids, i.e., with vapor pressures below 0.1 torr at 20 °C, to avoid freezing or boiling. All the liquids they discuss (water, methanol, acetonitrile, and mixtures thereof) are highly volatile and have vapor pressures much higher than 0.1 torr at 20 °C.

Jorgensen et al. also do not teach or fairly suggest the need to use solutions with relatively large electrical conductivities in order to form small drops and ions directly from the liquid meniscus or Taylor cone. Thus, Applicants' invention is therefore clearly distinguished from Jorgenson et al. by the limitations of low volatility and high conductivity set forth in claims 1 and 7, both of which are essential to the practice of Applicants' invention.

It is also important to note that Jorgenson et al. presumes to teach an improvement to the electrospraying technique of the prior art (i.e., Fenn et al., discussed at column 1, lines 17-40) without describing means to produce ions different from that used by the prior art. The presumed novelty in Jorgenson et al. is the claimed ability to produce the ions directly in a vacuum, or at smaller flow rates than in prior art.

However, Jorgenson et al. do not teach how ions would be produced from volatile liquids electrosprayed directly in a vacuum, where no hot and dry background is available to dry the electrospray drops. Nor does Jorgensen et al. explain how freezing or boiling of such liquids is to be avoided when they are exposed to the vacuum. The boiling and freezing problem is well known to those skilled in the art, which is why all serious prior attempts to form electrosprays in a vacuum have used either liquid metals or glycerol, as discussed in Applicants' specification. Jorgenson et al. simply presume that changing the background pressure will not disrupt the ion production mechanism of systems described in the prior art, but this presumption is known to be false to those skilled in the art. In order to electrospray into a vacuum, one needs low volatility liquids, which are not taught or suggested by Jorgenson et al. Jorgenson et al. do not teach or fairly suggest that in order for ions to be produced in a vacuum, in spite of the lack of drop evaporation, it is necessary that the ions be produced directly from the liquid meniscus. Nor do they teach that the formation of ions directly from the meniscus requires relatively high electrical conductivities. The restrictions of a vacuum environment tied to low volatility and high conductivity are therefore essential, but are no part of what Jorgenson et al (or any of the other cited references) have previously taught.

In conclusion, all the prior art cited by the Examiner (except for Jorgenson et al.) rely on high gas pressures to evaporate the solvent from the drops formed by electrospraying at ambient pressures. The presence of a bath gas and of solvent evaporation is essential for ions to be produced from the evaporating drops. In contrast,

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Applicants' claimed invention produces ions directly from the liquid meniscus held in a vacuum, and thus no evaporation is necessary.

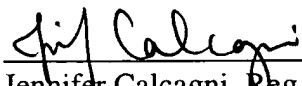
It is believed that claims 1-12, as amended, clearly define Applicants' invention over the prior art. Reconsideration and withdrawal of the rejection of claims 1-12 on the basis that the claims are clearly anticipated by Applicants' admission at page 2, line 11 though page 7, line 14 of the specification, Whitehouse et al. (5,844,237), Whitehouse et al. (5,306,412), Jorgensen et al. (5,115,131), and Wilm et al. is respectfully requested.

CONCLUSION

Applicants believe that the foregoing is a full and complete response to the Office Action of record. Accordingly, an early and favorable reconsideration of the rejection of all of the claims is requested. Applicants believe that claims 1-12 are now in condition for allowance and an indication of allowability and an early Notice of Allowance of all of the claims is respectfully requested.

If Examiner feels that a telephonic interview would be helpful, he is requested to call the undersigned at (203) 575-2648 prior to the issuance of the next office action.

Respectfully submitted,



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TABLE 1-4 Conversion Factors: U.S. Customary and Commonly Used Units to SI Units (Continued)

Quantity	Customary or commonly used unit	SI unit	Alternate SI unit	Conversion factor; multiply customary unit by factor to obtain SI unit
Volumetric heat-transfer coefficient	Btu/(s·ft ² ·°F) Btu/(h·ft ² ·°F)	kW/(m ² ·K) kW/(m ² ·K)		6.706 611 E + 01 1.862 947 E + 02
Surface tension	dyn/cm	mN/m		1
Viscosity (dynamic)	(lbf·s)/in ² (lbf·s)/ft ² (kgf·s)/m ² lbf/(ft·s) (dyn·s)/cm ² cP lbf/(ft·hr)	Pas Pas Pas Pas Pas Pas Pas	N·s/m ² N·s/cm ² N·s/m ² N·s/cm ² N·s/m ² N·s/m ² N·s/m ²	6.894 757 E + 03 4.788 026 E + 01 9.806 650* E + 00 1.488 164 E + 00 1.0* E - 01 1.0* E - 03 4.133 789 E - 04
Viscosity (kinematic)	ft ² /s in ² /s m ² /h ft ² /h cSt	m ² /s mm ² /s mm ² /s m ² /s mm ² /s		9.290 301* E - 02 6.451 6* E + 02 2.777 778 E + 02 2.580 64* E - 05 1
Permeability	darcy millidarcy	μm ² μm ²		9.869 233 E - 01 9.869 233 E - 04
Thermal flux	Btu/(h·ft ²) Btu/(s·ft ²) cal/(s·cm ²)	W/m ² W/m ² W/m ²		3.152 E + 00 1.135 E + 04 4.184 E + 04
Mass-transfer coefficient	(lb·mol)/(h·ft ² (lb·mol/ft ³)) (g·mol)/(s·m ² (g·mol/L))	m/s m/s		8.467 E - 05 1.0 E + 01
Electricity, magnetism				
Admittance	S	S		1
Capacitance	μF	μF		1
Charge density	C/mm ²	C/mm ²		1
Conductance	S Ω (mho)	S S		1 1
Conductivity	S/m Ω/m mΩ/m	S/m S/m mS/m		1 1 1
Current density	A/mm ²	A/mm ²		1
Displacement	C/cm ²	C/cm ²		1
Electric charge	C	C		1
Electric current	A	A		1
Electric-dipole moment	C·m	C·m		1
Electric-field strength	V/m	V/m		1
Electric flux	C	C		1
Electric polarization	C/cm ²	C/cm ²		1
Electric potential	V mV	V mV		1 1
Electromagnetic moment	A·m ²	A·m ²		1
Electromotive force	V	V		1
Flux of displacement	C	C		1
Frequency	cycles/s	Hz		1
Impedance	Ω	Ω		1
Linear-current density	A/mm	A/mm		1
Magnetic-dipole moment	Wb·m	Wb·m		1
Magnetic-field strength	A/mm Oe gamma	A/mm A/m A/m		7.957 747 E + 01 7.957 747 E - 04
Magnetic flux	mWb	mWb		1